The link between upper ocean biogeochemistry and the deep ocean: An example from a ten year time series in the Northeast Atlantic

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Much of the geological record in the deep ocean was created as a result of biogeochemical processes in the upper part of the water column. The factors that determine the rate and characteristics of primary production affect to a very large extent the rates at which material is lost from the upper ocean due to gravitational settling of particles. It is therefore of considerable importance for us to develop an understanding of the processes responsible for the time varying downward flux of particulate matter.

Since 1989 studies have been conducted at a single location on the Porcupine Abyssal Plain (PAP) in the Northeast Atlantic (4800m water depth)(Figure 1). The objective has been to examine the seasonal and interannual trends in downward particle flux, to elucidate the physical and biological factors that control this and to determine the influence of flux variations on the benthic community and the biogeochemistry of the upper few centimetres of the sediment.

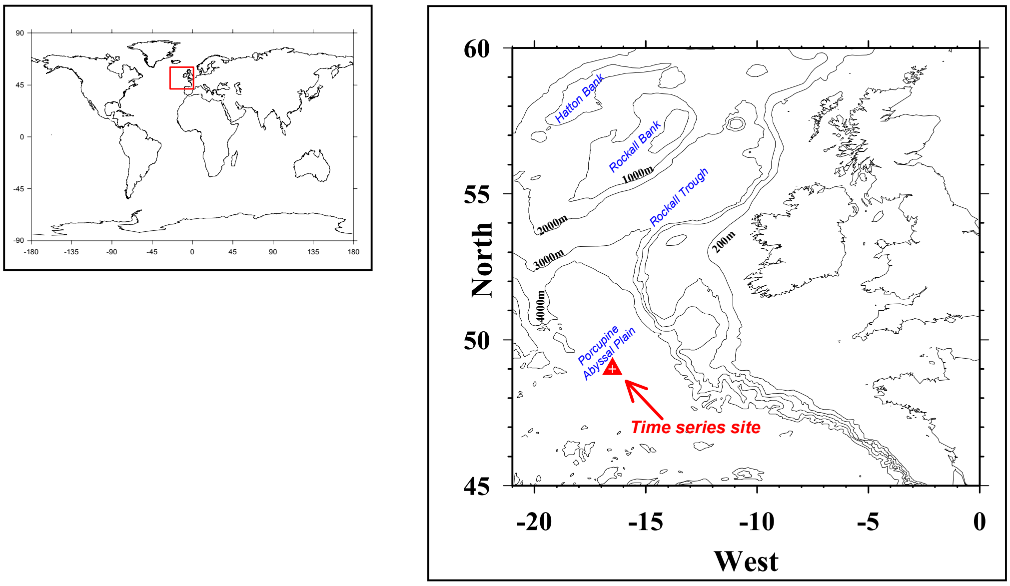

Figure 1. Location of the ten year study site in the Northeast Atlantic. The water depth is 4800m.

Daily meteorological data (Figure 2) have been used to drive a model of upper ocean biogeochemistry providing a derivation of particle export from the upper mixed layer and hence the flux in the deeper parts of the water column. These model results are compared to downward particle flux measured using time series sediment traps at 3000m depth (1800m above bottom). The depth of winter convection varies by more than a factor of two, interannual variation in the measured timing of the major particle flux peaks varies by one month (Figure 3) and integrated annual flux by a factor of 1.5 (Figure 4). There is close agreement between the model output of flux at 3000m depth and that measured by sediment trap although neither show a consistent trend of increasing or decreasing flux over this decade (Figure 4). The model output is also compared to semi-quantitative estimates of the time varying benthic load of phytodetrital material and midwater concentrations of marine snow both derived using time lapse photography.

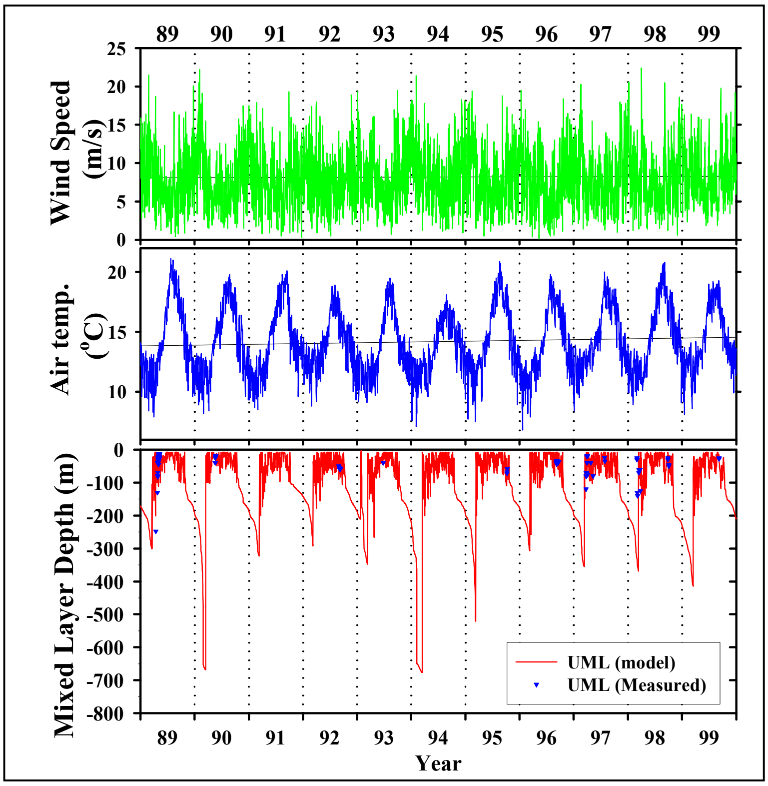

Figure 2. Variation in meteorological forcing over the Porcupine Abyssal Plain and the effect on the depth of the upper mixed layer. Deeper mixing introduces more nutrients into the upper sunlit zone leading to enhanced primary production and hence greater downward particle flux. Air temperature and wind speed were taken from NCEP re-analysis provided by NOAA-CIRES, Climate Diagnostics Center, Boulder, Colorado, USA from their web site (http:// www.cdc.noaa.gov/).

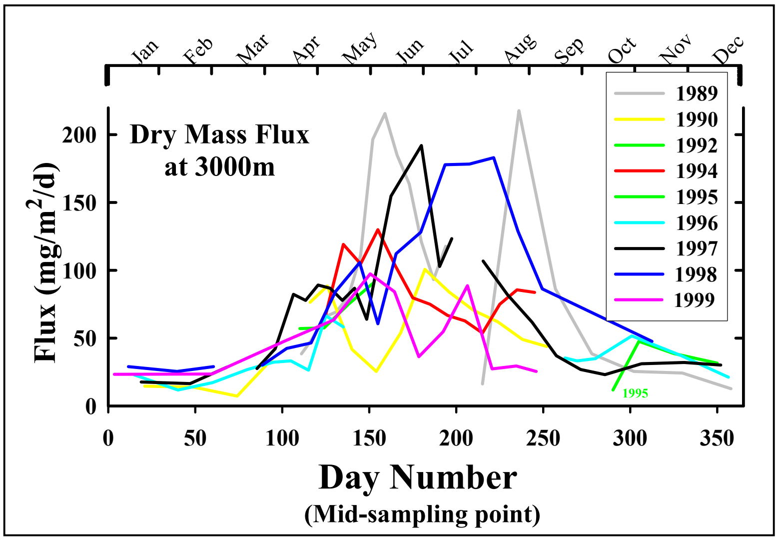

Figure 3. Downward flux of the dry mass of particulate material at 3000m over the Porcupine Abyssal Plain. Each data point represents the average flux over a predetermined period of time which may be as short as a week but during periods of constant flux such as in the winter, longer sampling intervals were selected.

The biological community of the underlying sediment has changed markedly over this time period with dramatic increases in the population size of some large benthic species which were previously rare. The expectation was that explanation for this would be found in the primary supply of organic material to the seabed. Similarly the phytodetrital layer that has previously been a prominent feature on the seabed in early summer has not been observed since 1996. To date the causes of this change in community structure have not been elucidated and may be related to subtle qualitative changes in the food supply rather than to changes in the integrated annual organic carbon flux.

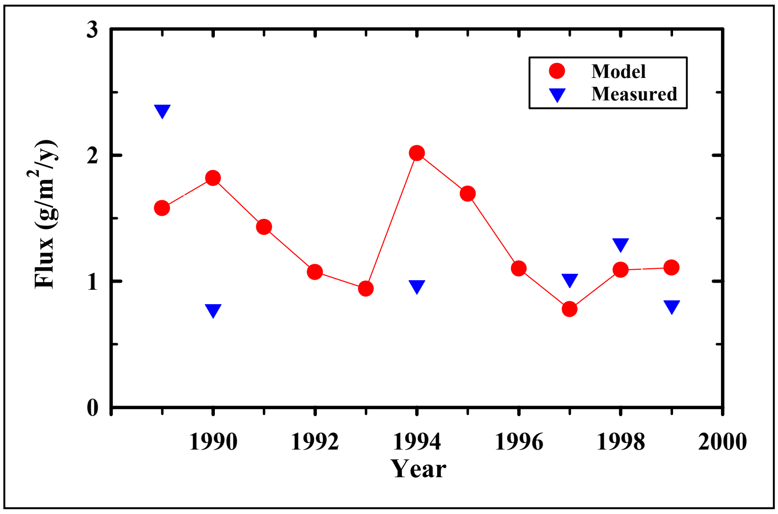

Figure 4. Annual integrated downward flux of organic carbon at 3000m depth as determined by the model driven by upper ocean biogeochemistry and as measured by sediment traps at that depth.